

RECONCILE

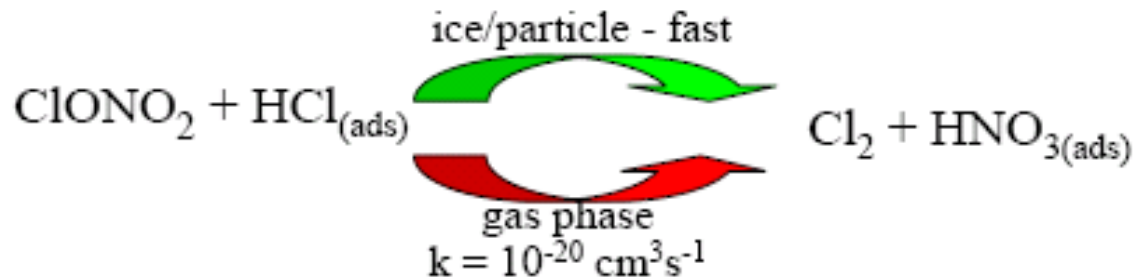
Reconciliation of essential process parameters for an enhanced predictability of arctic stratospheric ozone loss and its climate interactions

Project Overview

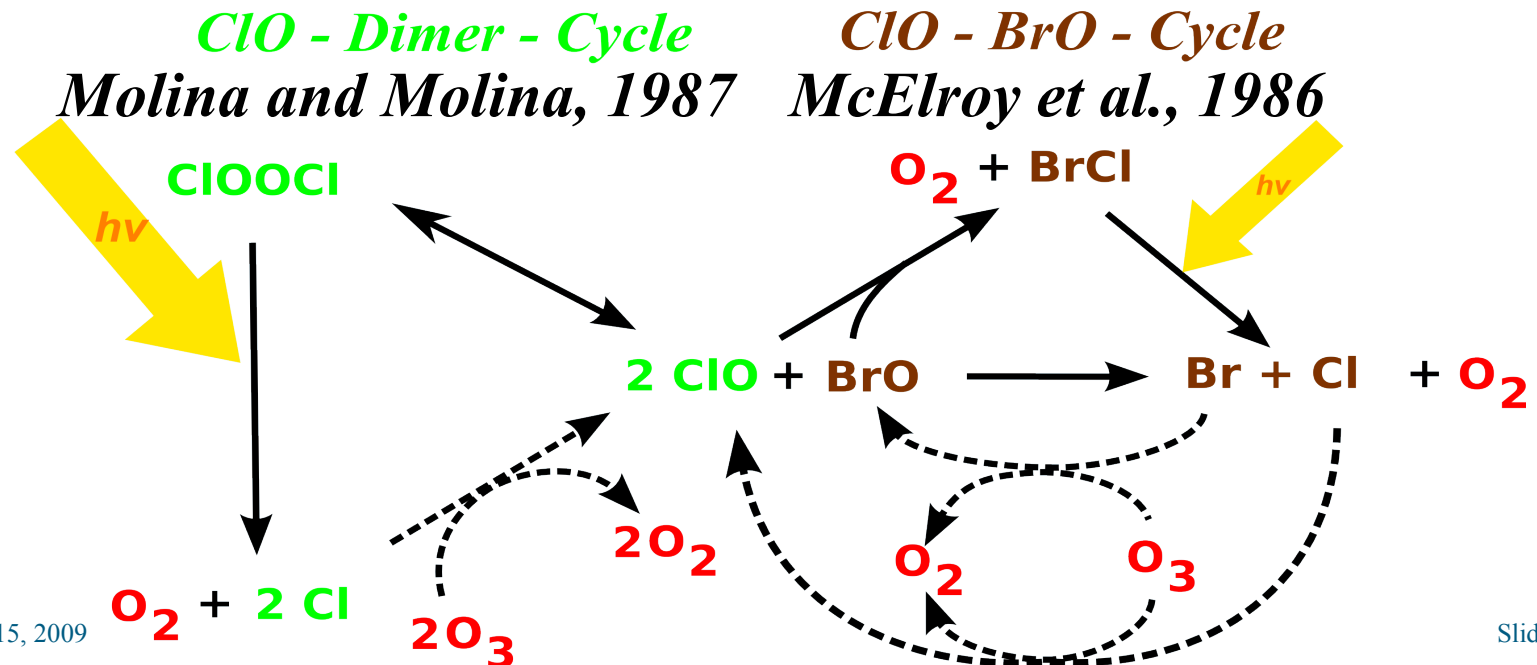
Jens-Uwe Groöb, Forschungszentrum Jülich, and the RECONCILE Team

How to make an ozone hole ?

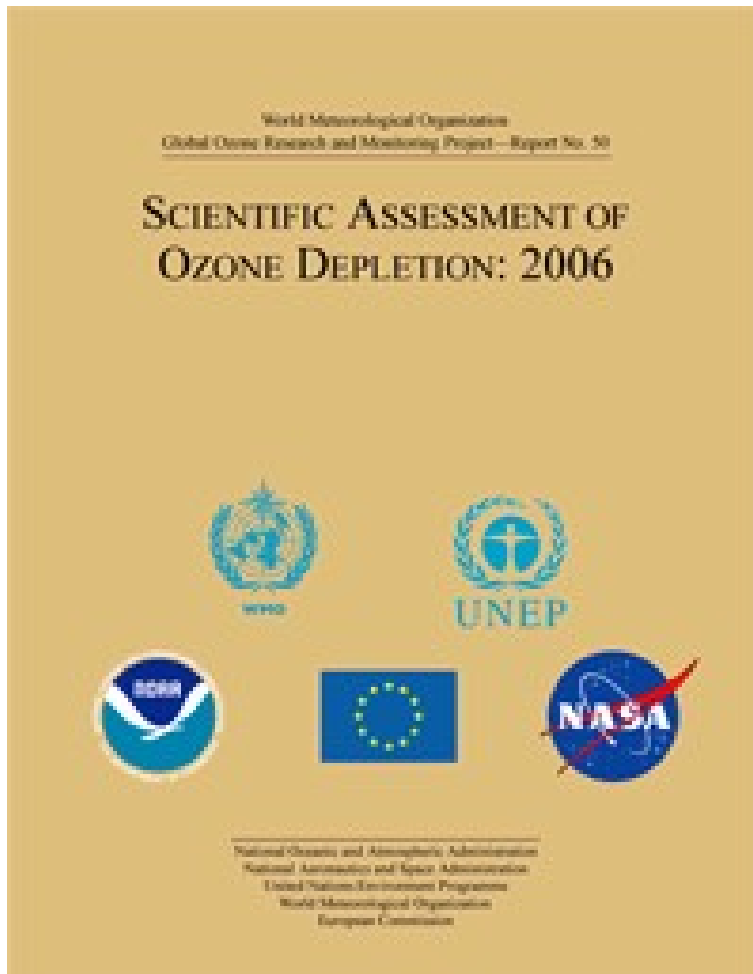
1. The chemical isolation of the polar vortex
2. Heterogeneous Cl activation on PSCs (*Solomon et al., 1986*)



3. Catalytic cycles that rapidly destroy O_3 at cold T + high SZA



Polar stratospheric ozone loss is considered to be reasonably well understood. Observed O₃ loss is reproduced by models (CTMs), and future developments can be predicted with reasonable certainty.

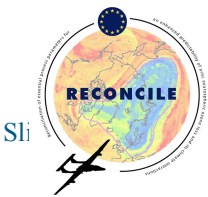


„The role of chemical reactions of chlorine and bromine in the polar stratosphere is better quantified. Inclusion of these advances results in improved agreement between theory and observation of the timing of both Arctic and Antarctic polar ozone loss.“

WMO Ozone Assessment 2006, Executive Summary for Policy Makers

Why another Polar Ozone project?

September 15, 2009

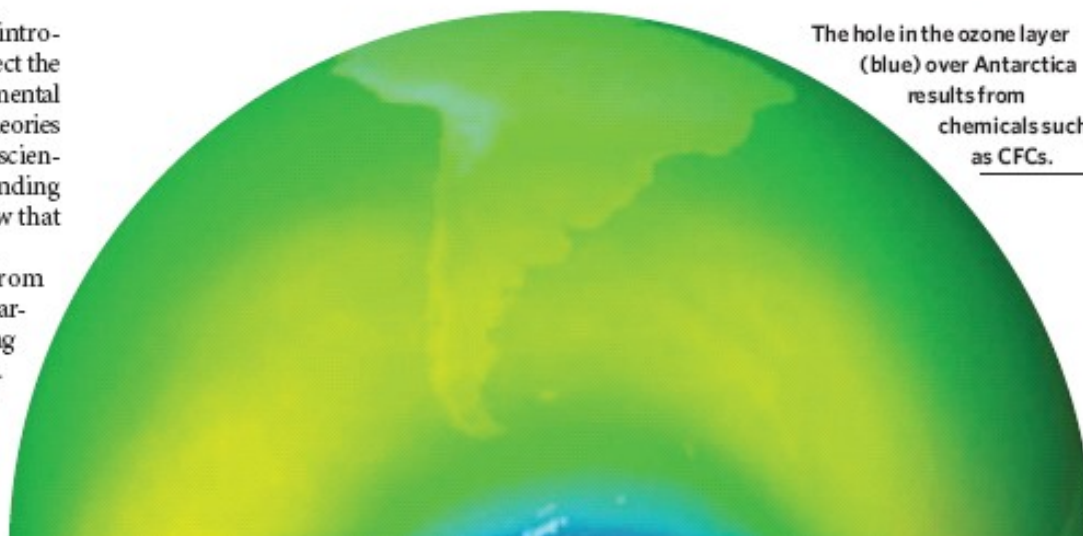


NEWS

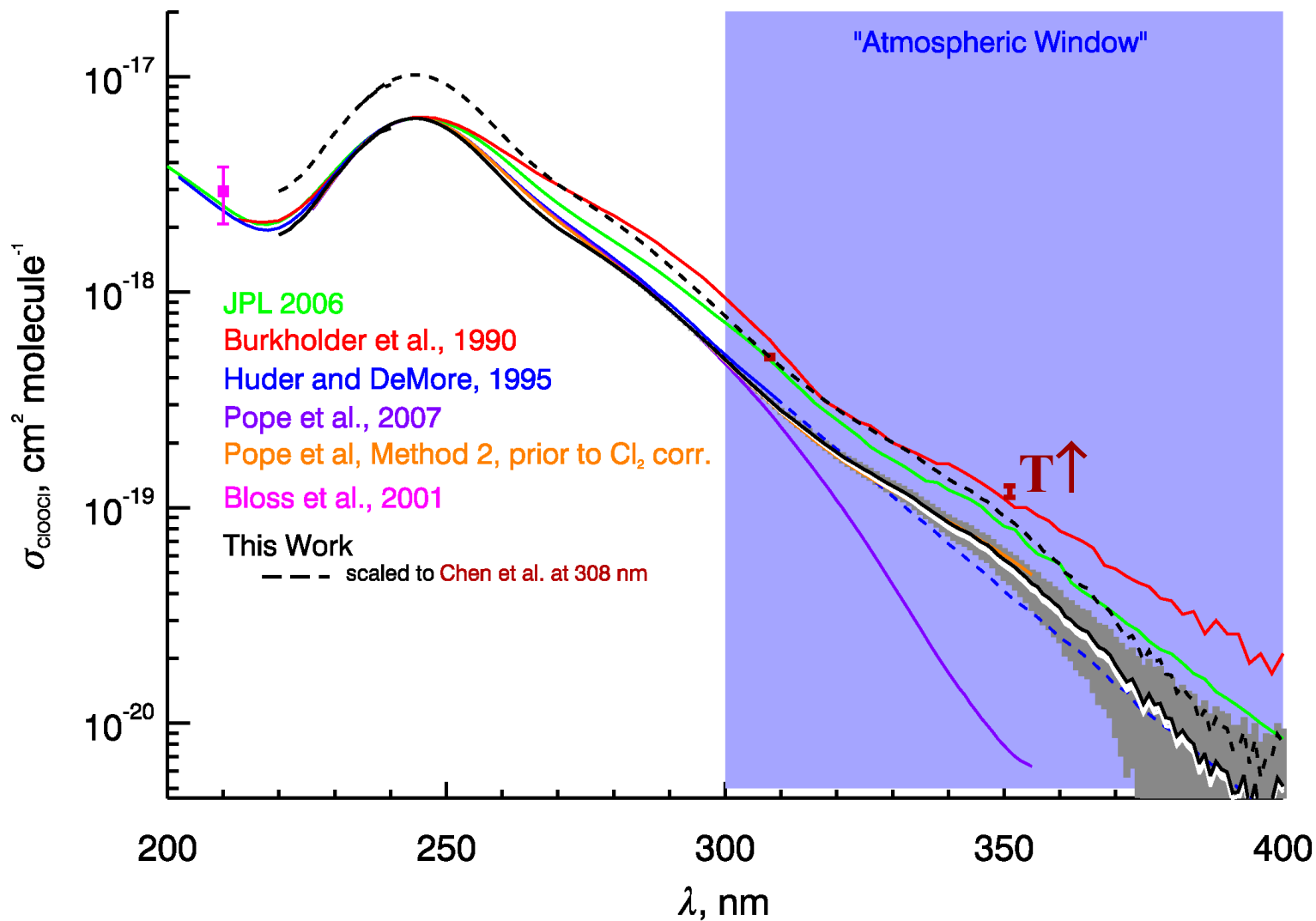
Chemists poke holes in ozone theory

As the world marks 20 years since the introduction of the Montreal Protocol to protect the ozone layer, *Nature* has learned of experimental data that threaten to shatter established theories of ozone chemistry. If the data are right, scientists will have to rethink their understanding of how ozone holes are formed and how that relates to climate change.

Long-lived chloride compounds from anthropogenic emissions of chlorofluorocarbons (CFCs) are the main cause of worrying seasonal ozone losses in both hemispheres. In 1985, researchers discovered a hole in the ozone layer above the Antarctic, after atmospheric chloride levels built up. The Montreal Protocol, agreed in 1987 and ratified two years later, stopped



More than 20 years after the discovery of the Ozone Hole and the ratification of the Montreal Protocol, a new laboratory experiment by *Pope et al.* (*J. Phys. Chem.*, 2007) suggests much smaller photolysis rate of ClOOCl.



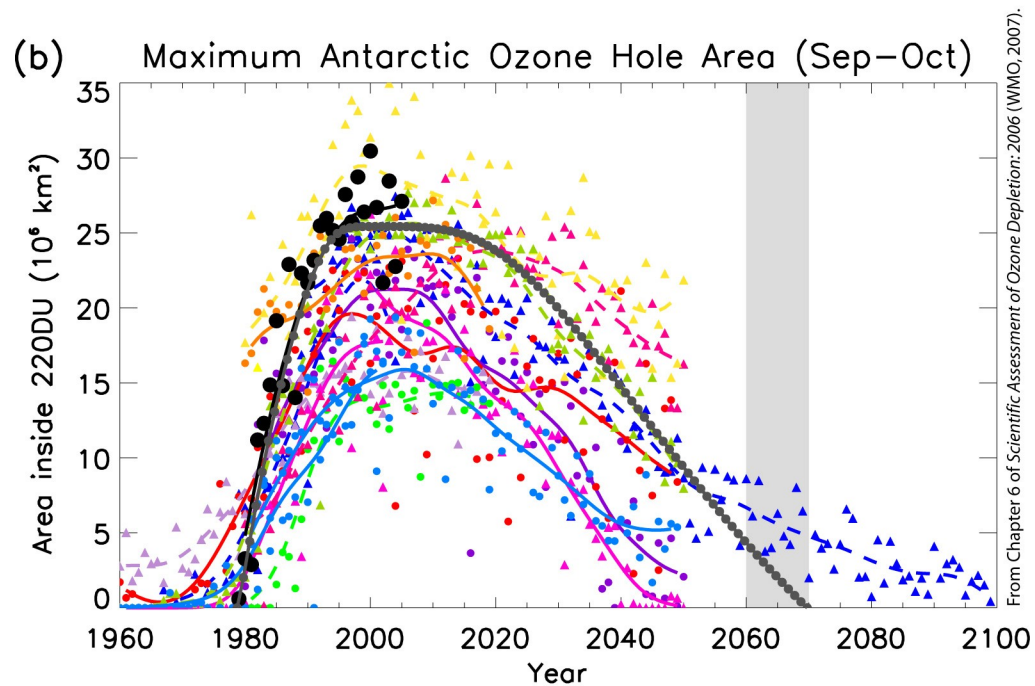
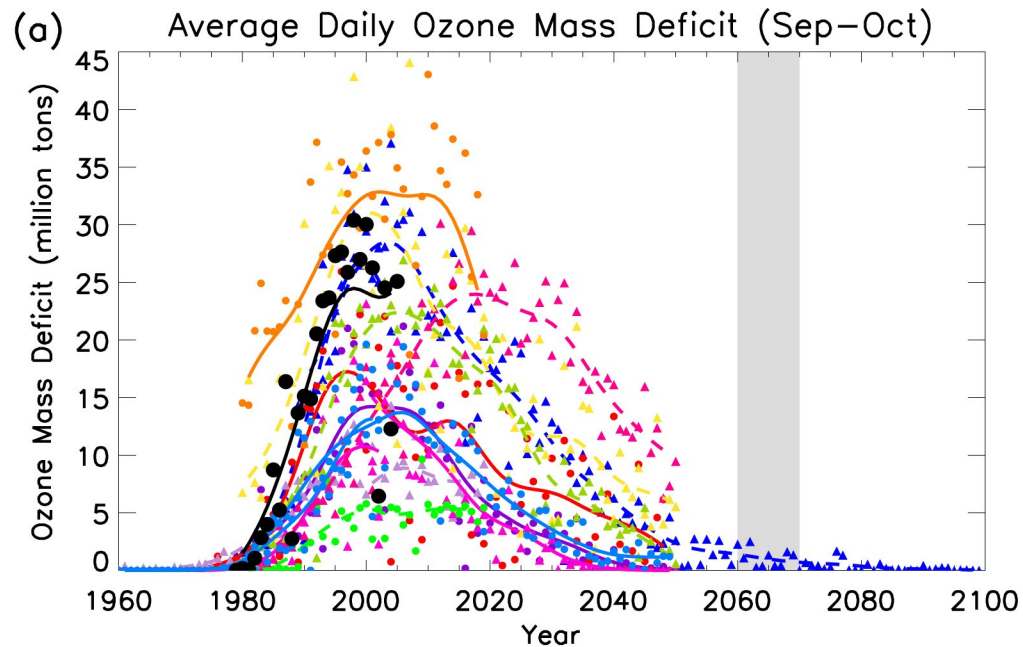
von Hobe, M., F. Stroh, H. Beckers, T. Benter, and H. Willner. 2009. The UV/Vis absorption spectrum of matrix isolated dichlorine peroxide, ClOOC1 , *Phys. Chem. Chem. Phys.*, DOI:10.1039/B814373K. <http://www.rsc.org/publishing/journals/CP/article.asp?doi=B814373K>

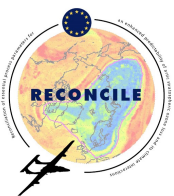
RECONCILE Description of Work:

„Yet, recent publications of new absorption cross sections for the ClO dimer (Pope et al., 2007) – the central chlorine species in polar stratospheric ozone depletion – have disturbed the atmospheric community (Schiermeier, 2007; von Hobe, 2007) and have revealed that this most obvious man-made atmospheric phenomenon is in many respects still not adequately understood and significant uncertainties exist on the key parameters determining the rate of catalytic ozone destruction in polar spring.“

RECONCILE
is NOT about Pope
et al. !!!

- Cl_2O_2 absorption cross sections
- Chlorine activation on liquid or solid particles
- The amount of Br_y in the stratosphere
- Nucleation rate of NAT particles
- Mixing of air through the vortex edge and its effect on ozone loss estimates
- Realization of these processes in global models





RECONCILE Objectives

- I. Reach **quantitative understanding of the chemistry** leading to polar ozone depletion
- II. Improve our **understanding of PSC microphysics and heterogeneous chlorine activation**
- III. Quantify the **flux and mixing of air through the vortex edge** and its impact on polar and mid-latitude ozone

→ key processes dominating **chemistry**, **microphysics**, and **dynamics**

Through dedicated **laboratory** and **field measurements** improve **model representations of key processes**

- IV. Incorporate the improved parameterisations resulting from objectives I – III into a **Chemistry Climate Model (CCM)** to generate **more reliable predictions** for the future evolution of the ozone layer and its effects and sensitivities to climate, and **test the improved CCM simulations against observed trends.**

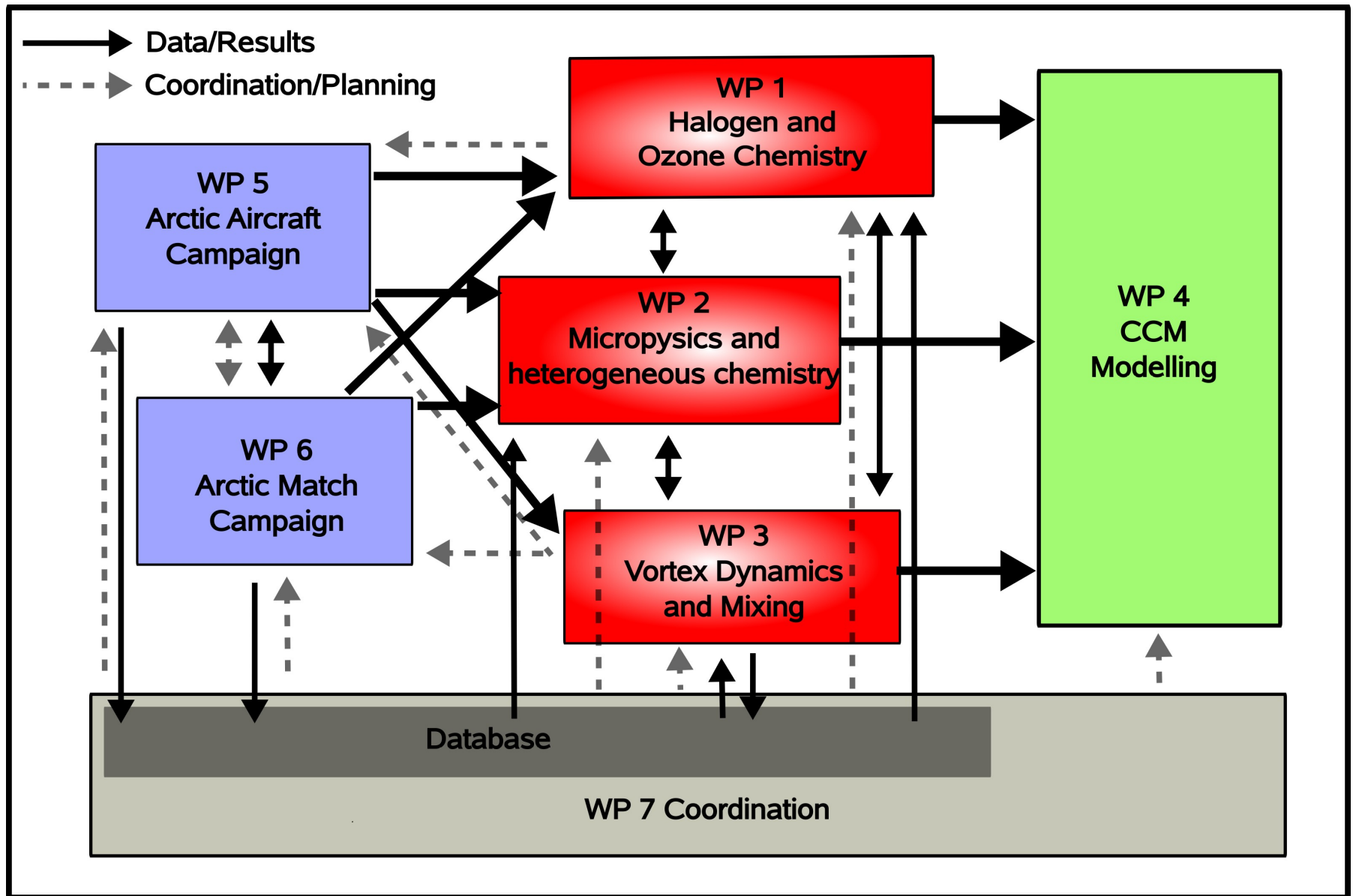
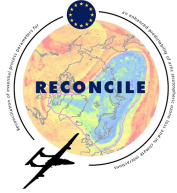
RECONCILE Overview

Coordinator: Marc von Hobe (JÜLICH)
Project Duration: March 2009 – February 2013
Activities: Lab, Aircraft Campaign, Global model
Campaign: January 2010 – March 2010 (2x ~3weeks)
Geophysica aircraft in Kiruna (Sweden)
Match Campaign: O₃, H₂O aer backscatter

RECONCILE public web site: <https://www.fp7-reconcile.eu>

RECONCILE is open to associated partners

RECONCILE Structure



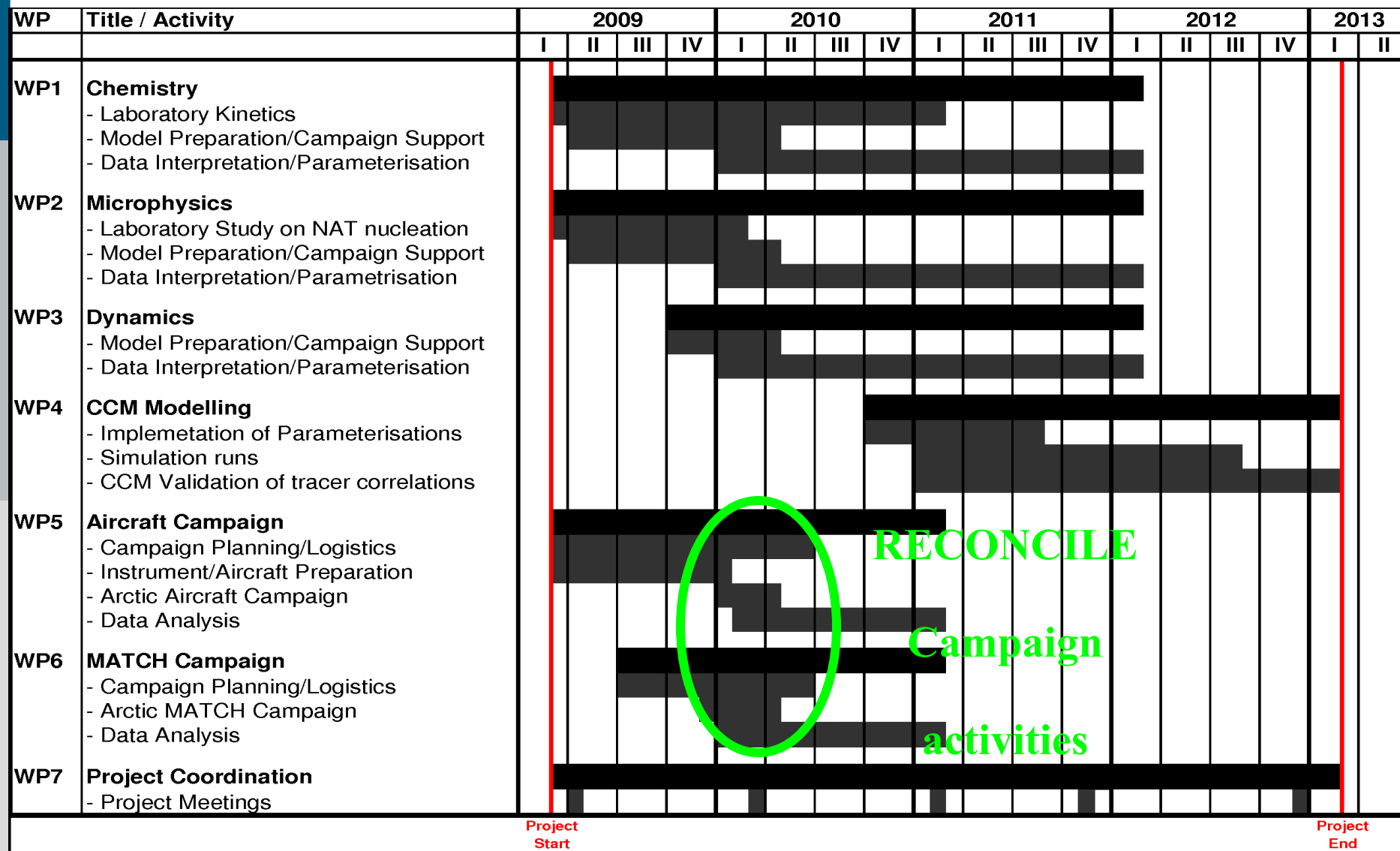
RECONCILE Consortium

17 partners from 9 countries

Beneficiary Number *	Beneficiary name	Beneficiary short name	Country
1(coordinator)	Forschungszentrum Jülich	Jülich	Germany
2	University of Cambridge	UCAM	United Kingdom
3	Deutsches Zentrum für Luft- und Raumfahrt	DLR	Germany
4	Alfred-Wegener-Institut	AWI	Germany
5	Swiss Federal Institute of Technology	ETHZ	Switzerland
6	Norwegian Institute for Air Research	NILU	Norway
7	CNRS, Service d'Aeronomie	CNRS	France
8	University of Wuppertal	BUW	Germany
9	Max Planck Society	MPG	Germany
10	Centre Suisse d'Electronique et de Micro-technique	CSEM	Switzerland
11	Consiglio Nazionale Delle Ricerche	CNR	Italy
12	Central Aerological Observatory	CAO	Russia
13	University of Heidelberg	UHEI	Germany
14	Forschungszentrum Karlsruhe	FZK	Germany
15	Eötvös University Budapest	ELTE	Hungary
16	Jet Propulsion Laboratory	JPL	USA
17	United Kingdom Meteorological Office	UKMO	United Kingdom

The M55 operator STM/MDB will be subcontractor of Jülich

RECONCILE Timeline

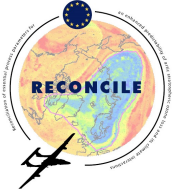


RECONCILE Campaign activities

PAYLOAD OF M55-GEOPHYSICA:

- Measurements of reactive chemical species **ClO, Cl₂O₂, ClONO₂, OCIO, BrO, NO, NO_y** [HALOX, miniDOAS, SIOUX]
- Measurements of tracer species **N₂O, CH₄, O₃, H₂O, CO, CFC-11** [HAGAR, FISH, FOZAN, COLD, FOX]
- Measurements of the **number density** and **size distributions** and **NO_y content of aerosols** and PSC particles [FSSP, CIP, CCP, COPAS, SIOUX]
- Measurements of **aerosol and cloud backscatter** and depolarisation by miniature lidar [MAS]
- **Remote sensing measurements** of chemical species [CRISTA-NF, MIPAS, MARSHALS]
- Measurements of **meteorological parameters, air pressure, temperature, wind** [MTP,...]

RECONCILE Campaign activities



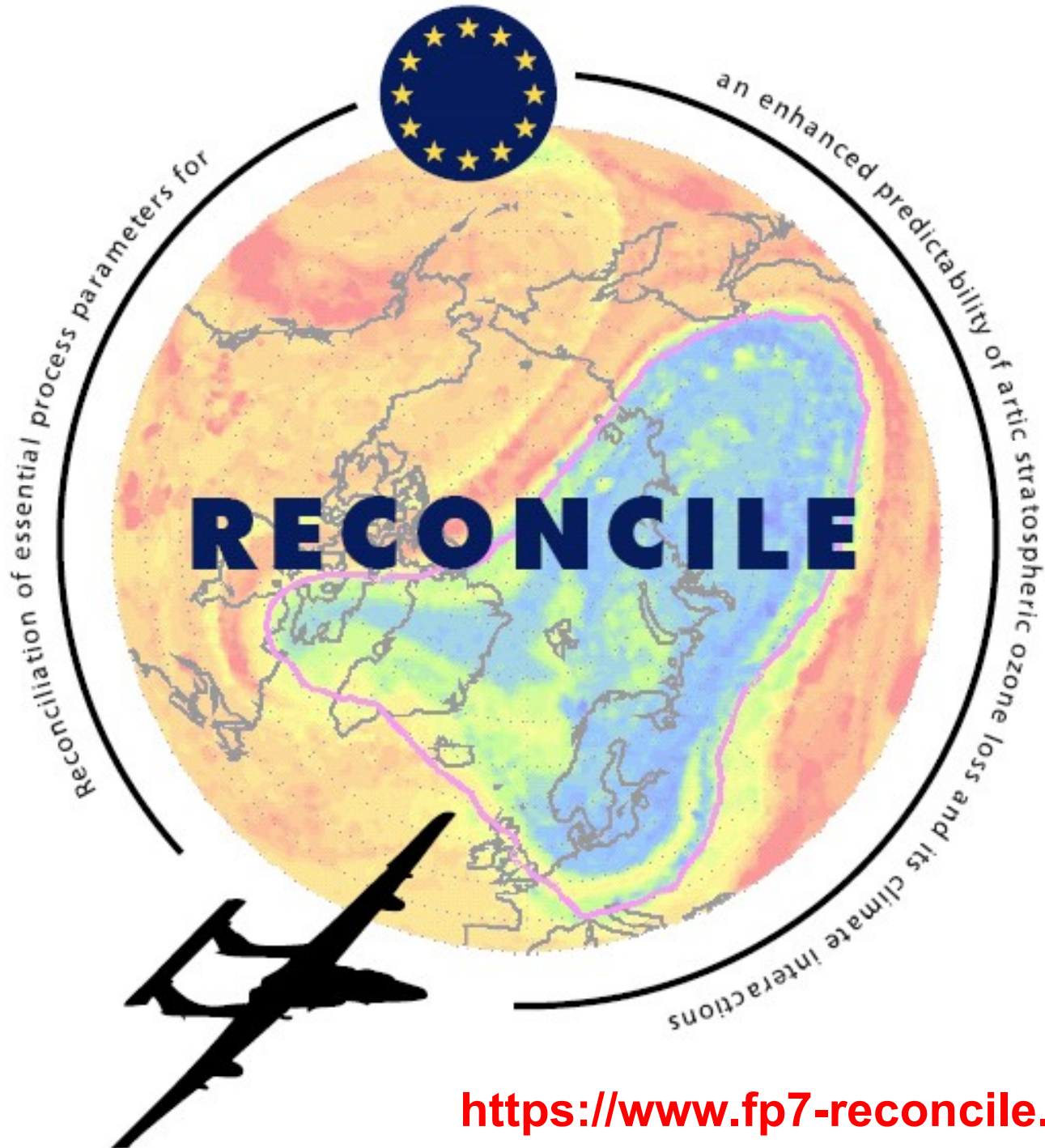
PLANNED FLIGHTS OF M55-GEOPHYSICA:

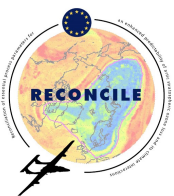
- Flights under low temperature conditions to fulfil microphysics and heterogeneous chemistry objectives
- Survey flights into different regions of the vortex and across the vortex edge
- Self-Match flights over sunrise to fulfil chemistry objective

RECONCILE Campaign activities

PLANNED ASSISTANCE TO FLIGHTS:

- Flight planning involves many model groups including CLaMS (JÜLICH)
- CLaMS model forecasts to a possible flight day are planned
- Simulations will be initialized and validated using most recent available AURA-MLS (O_3 , HCl, ClO, N_2O) and ACE-FTS data (O_3 , HCl, $ClONO_2$, N_2O)

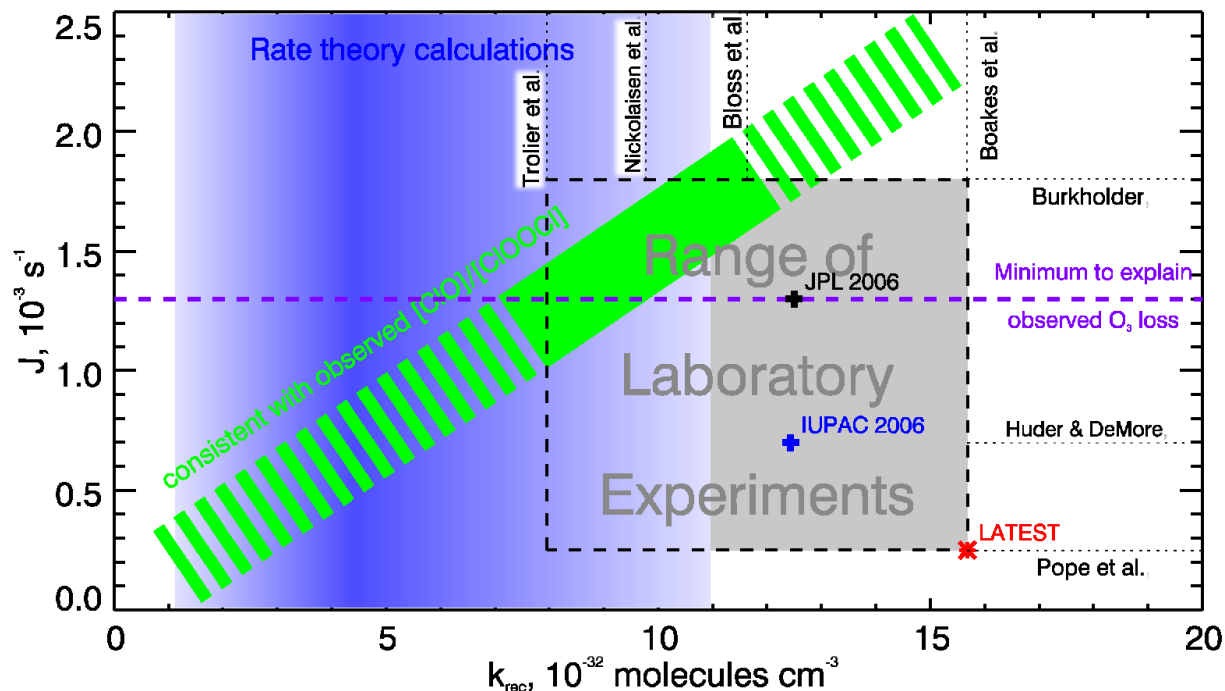




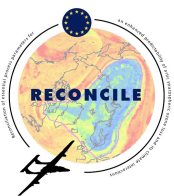
Open Questions

I. Reach *quantitative* understanding of the chemistry leading to polar ozone depletion

- Lab experiments to reconcile discrepancies of J , k_f , K_{eq}
- Self-Match-flights over sunrise
→ constrain J , k_f , K_{eq} better than previous observations.



- Use discrepancies between the improved laboratory constraints and observations to test for and constrain any missing chemistry.

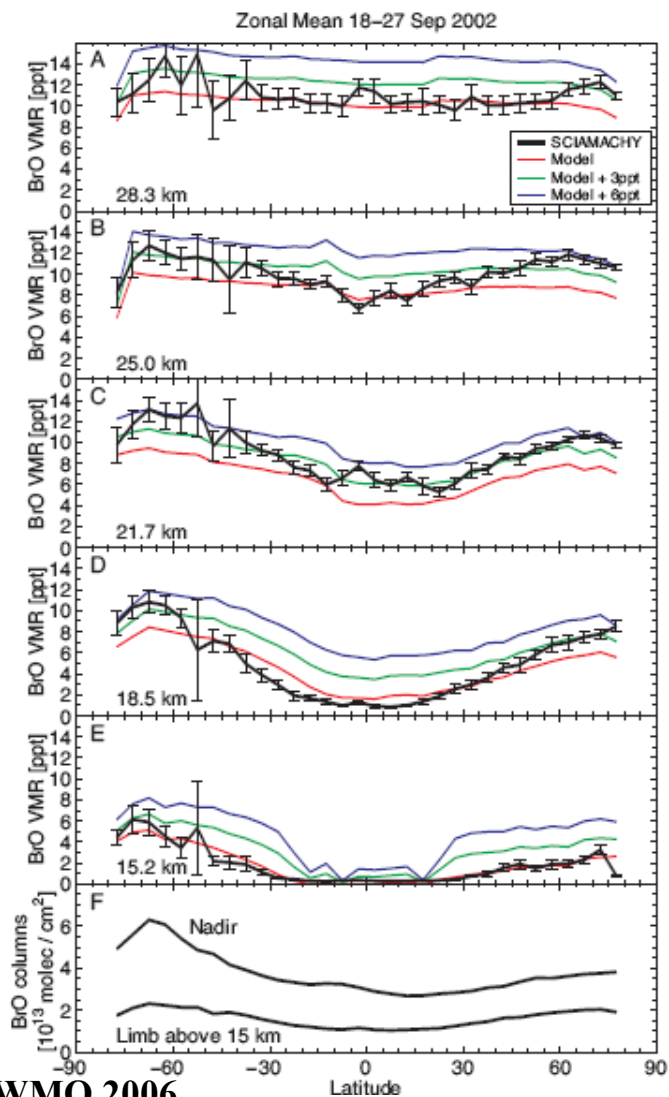
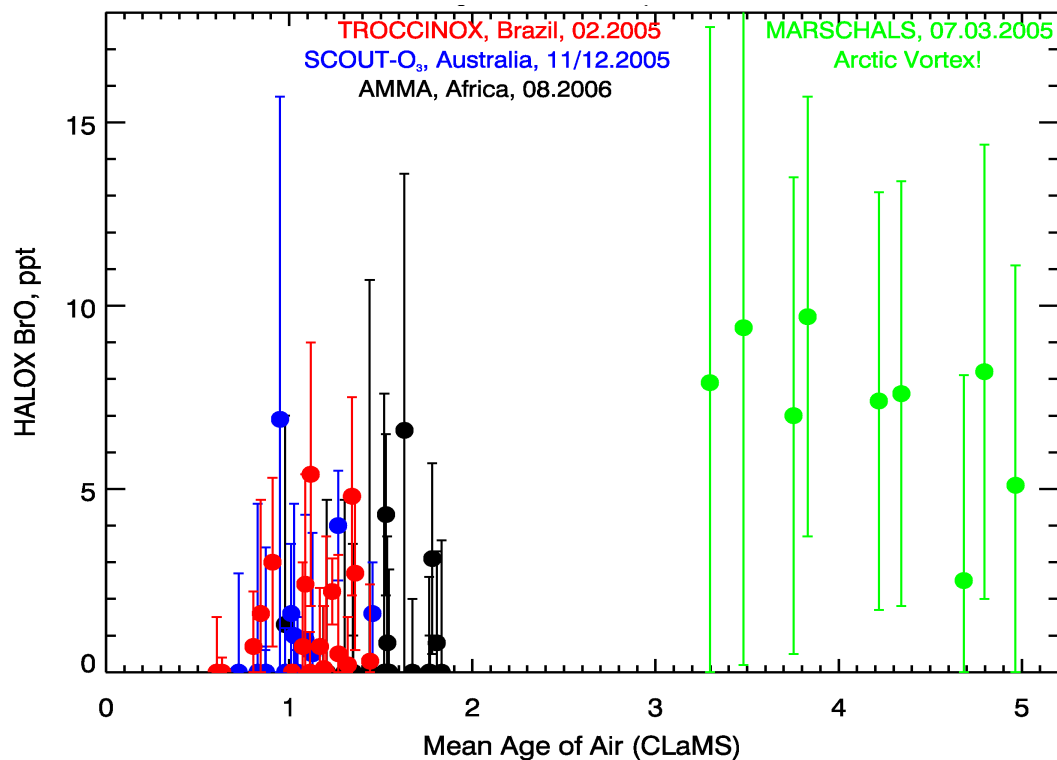


Open Questions

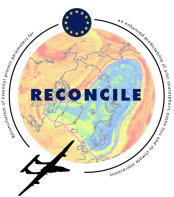
I. Reach *quantitative* understanding of the chemistry leading to polar ozone depletion

How much inorganic bromine is present and how much does it contribute to polar O₃ loss?

Comprehensive set of BrO measurements with two independent instruments (CCRF and DOAS) in aged vortex air



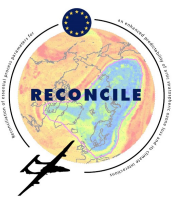
from WMO 2006



Open Questions

I. Reach *quantitative* understanding of the chemistry leading to polar ozone depletion

- Are there alternative mechanisms for O_3 destruction in polar winter?
- Exactly how consistent is theoretical O_3 loss with observed loss rates?
- What can discrepancies tell us about additional ozone destruction mechanisms?
- Laboratory investigations of some recently proposed new or altered O_3 destruction mechanisms (Cl_2O_2 isomers, heterogeneous destruction)
- Comparison of modelled to observed O_3 loss from Match sondes and long-term Match flights performed by the Geophysica (marking air masses with artificial tracers) with trajectories that minimise uncertainty due to dynamics and mixing.



Open Questions

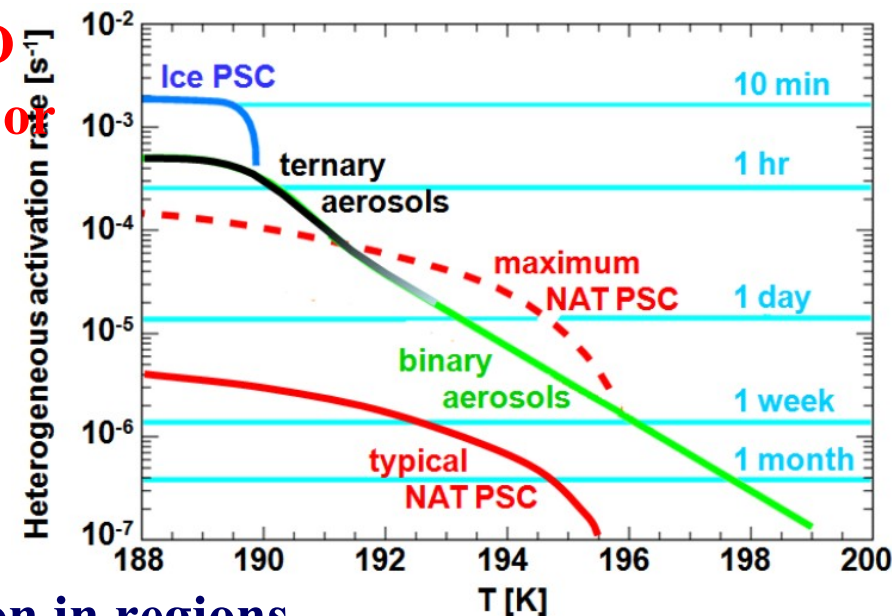
II. Improve our understanding of PSC microphysics and heterogeneous chlorine activation

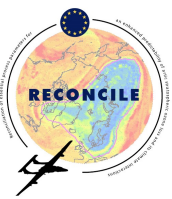
Does the cold liquid binary $\text{H}_2\text{SO}_4/\text{H}_2\text{O}$ aerosol suffice to activate the chlorine or are liquid ternary $\text{HNO}_3/\text{H}_2\text{SO}_4/\text{H}_2\text{O}$ PSCs required?

Uncertainties regarding the exact mechanism of activation: PSCs or cold aerosols? (Drdla, AGU 2005)

Probe air masses for chlorine activation in regions where only one of these particle types exists.

Evaluations of T data from ECMWF meteorological analyses show that below about 430 K potential temperature, air masses can be found that are below the chlorine activation threshold temperature according to Drdla (2005) but still above the threshold for NAT formation.





Open Questions

II. Improve our understanding of PSC microphysics and heterogeneous chlorine activation

How does NAT nucleation leading to large denitrifying particles work, in particular how important is heterogeneous NAT nucleation on meteoritic or other nuclei?

- flights in air masses with temperatures that recently have dropped below T_{NAT} or below T_{STS} .
- Laboratory experiments using meteoritic particles in/on $\text{HNO}_2/\text{H}_2\text{SO}_4/\text{H}_2\text{O}$ solutions to re-examine the upper limits for nucleation (Biermann et al., 1996).



Open Questions

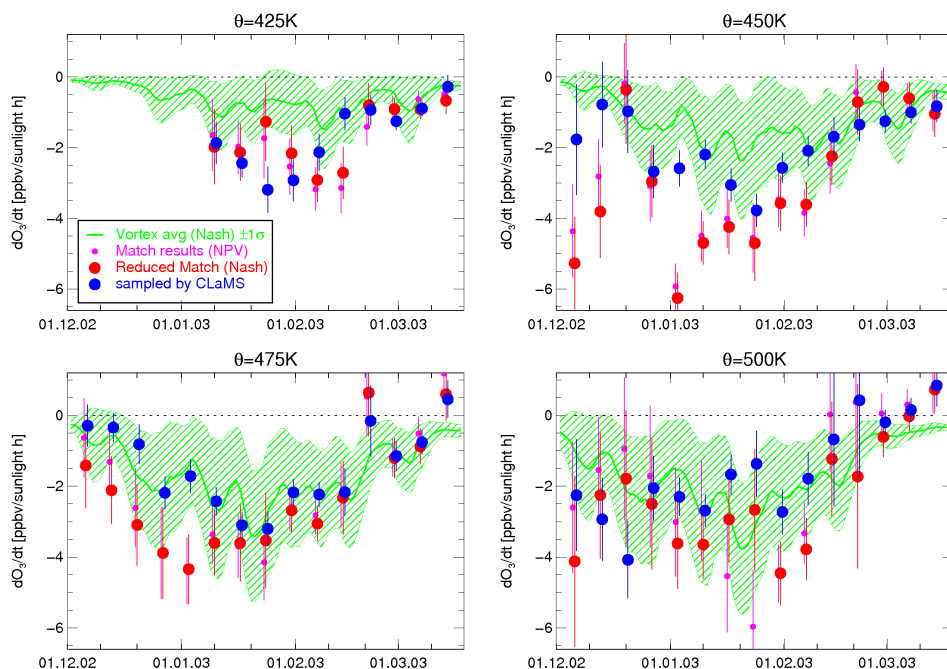
III. Quantify the flux and mixing of air through the vortex edge and its impact on polar and mid-latitude ozone

How intense is the transport of air masses through the vortex edge in both directions?

- Observation of relations of trace species with different atmospheric lifetime in the early polar vortex and during a later time in winter.
- Probe the variability of the tracer-tracer relation over different parts of the vortex (core, edge)
- Compare with CTM simulations to investigate the amount of air that had been mixed into the polar vortex.

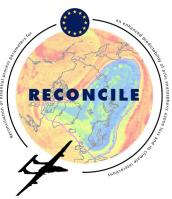
III. Quantify the flux and mixing of air through the vortex edge and its impact on polar and mid-latitude ozone

How does transport through the vortex edge influence estimates of polar ozone depletion?



CLaMS ascribes part of the *chemical* O_3 loss estimated by the Match method to mixing (from Grooß et al., ACP, 2008)

- Assimilation of O_3 satellite observations to calculate local O_3 loss over the northern hemisphere mid and high latitudes
- Testing of an improved control variable to improve the preservation of O_3 gradients.
- Use assimilated O_3 maps to benchmark O_3 observations from e.g. Geophysica Match flights, and to perform case studies of mixing episodes.



Open Questions

III. Quantify the flux and mixing of air through the vortex edge and its impact on polar and mid-latitude ozone

How can the representation of the transport barrier in CCMs be improved?

Compare CCM results to validated CTM results to improve the representation of the transport barrier in the CCM.

IV. Incorporate the improved parameterisations resulting from objectives 1 – 3 into a Chemistry Climate Model (CCM) to generate more reliable predictions for the future evolution of the ozone layer and its effects and sensitivities to climate, and test the improved CCM simulations against observed trends.

How well does the improved CCM describe past and present observations of ozone and other important parameters?

Compare CCM results to the observations

How well do CCMs describe the observed long range scaling (persistence) in total O₃ time series?

Calculation of DFA (detrended fluctuation analysis) scaling exponents from observed and simulated long time series of total ozone